Infantry & Small Arms Symposium

Non-lethal Technology Research at the Army Research Laboratory

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Research Topics

- Directed energy vehicle stopper system
- Electrical-driven acoustic source & field test experiments
- Vortex ring gun system

Vehicle Stopper Project Connectivity

Sponsor, Joint Nonlethal Weapons Directorate

- **Kevin Stull (stullk@quantico.usmc.mil)**

Developers, ARDEC and ARL

- **Edward Persau (ecpers@pica.army.mil)**
- **Mark Berry (mberry@arl.mil)**

Contractors

- **Titan/Beta (Reltron tube)**
- **Berkeley Research (power supply)**
- **NorthStar (modulator)**
- **MRC (prototype design support)**

Objectives

- Military: Deny access of vehicles to specific areas using non-lethal means
- Law Enforcement: Develop a nonlethal means of stopping vehicles in lieu of dangerous high speed chases
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Vehicle Stopper Technique

- Microwave (Reltron) System
  - System, contains generators, power conditioning system, tube, and antenna
  - Pulsed ?waves radiated by high gain antenna
  - Tune across frequency band to find vehicle susceptibilities
- Microwaves pass through “ports-of-entry” of vehicle (e.g., windows, body gaps, seams, etc.)
- Energy couples into electronic boxes & wiring
  - Affects electronic engine control computer
  - Causes computer to act on or generate false signals and change fuel injection performance

Test Vehicles

- 1987 Mercedes Benz 300E
- 1988 Chevrolet Blazer
- 1988 Toyota Pickup
- 1989 Dodge Dakota Pickup Truck
- 1989 Ford Probe
- 1990 Toyota Corolla
- 1990 Ford Taurus
- 1993 Cadillac Fleetwood
- 1998 Volkswagen Jetta TDI
- 1998 Chevrolet C3500 Diesel Pickup

Test Vehicle on Dynamometer

ARL Experimental Results

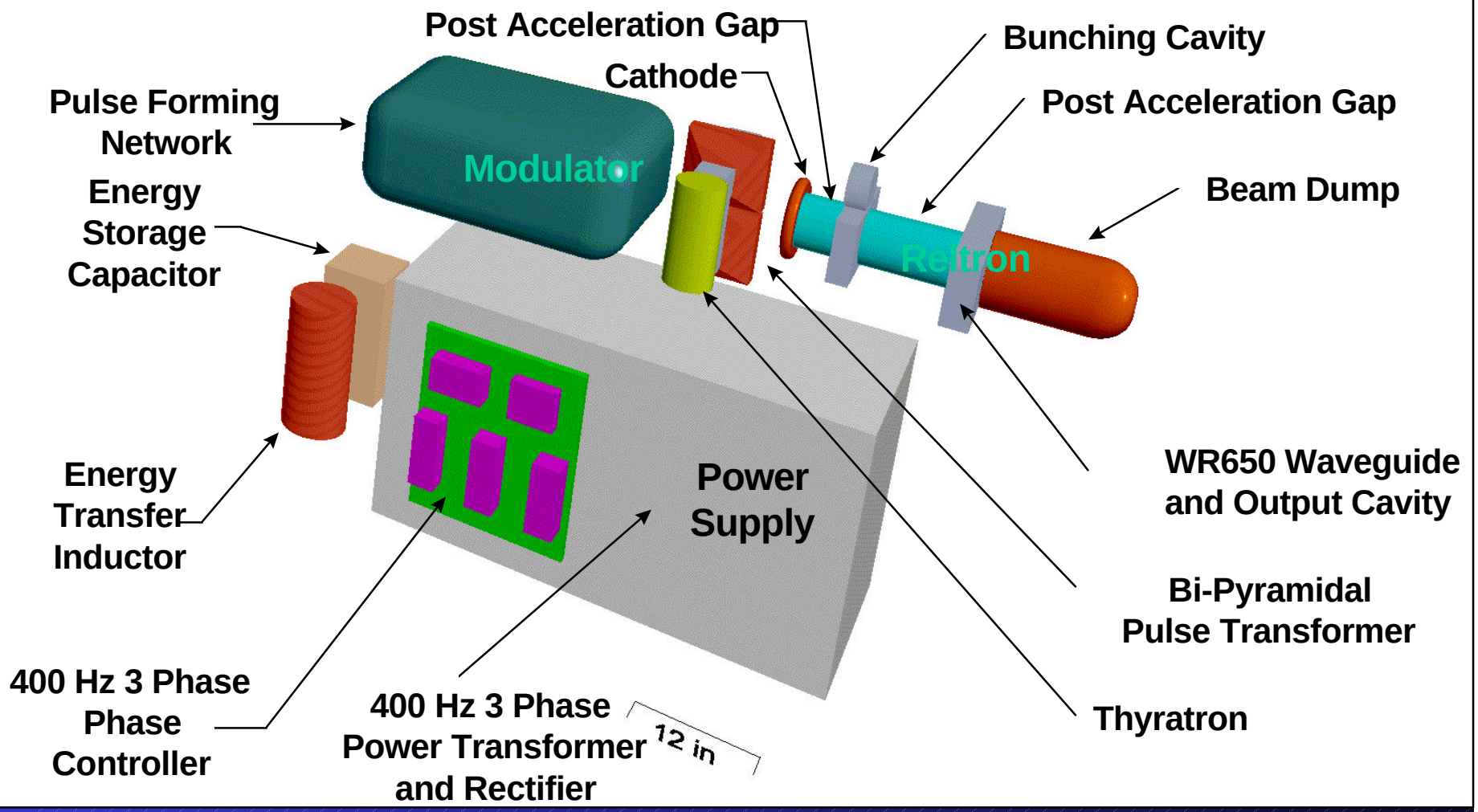
- Slowed or stopped all vehicles on dynamometer (gasoline and new diesels)
  - Power densities on dynamometer consistent with idle data
  - Vehicle orientation not a critical parameter
- Field levels below IEEE PEL (when adjusted for averaging time and duty factor)

Reltron Source Parameters

- Peak power: 50 MW
- Antenna gain: 30 dBi
- Pulse width: 2 ?s
- PRF: 0 to 300 Hz
- Range: 200 m (30 dBi gain, 6 deg beamwidth)
- Power density at range: > 10 W/cm^2

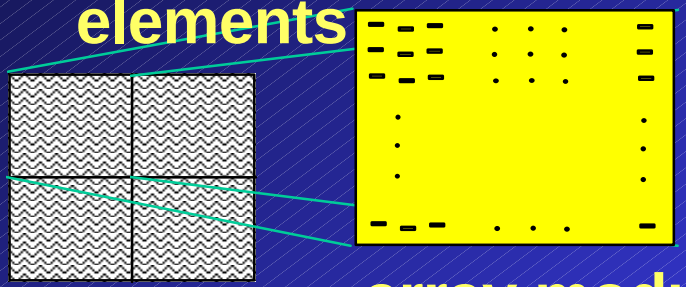

20-MW Reltron

Brassboard Reltron System



Waveguide Slotted Array Antenna

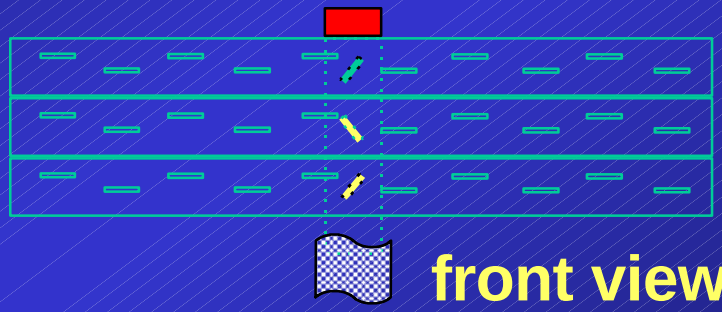
10 x 10 elements



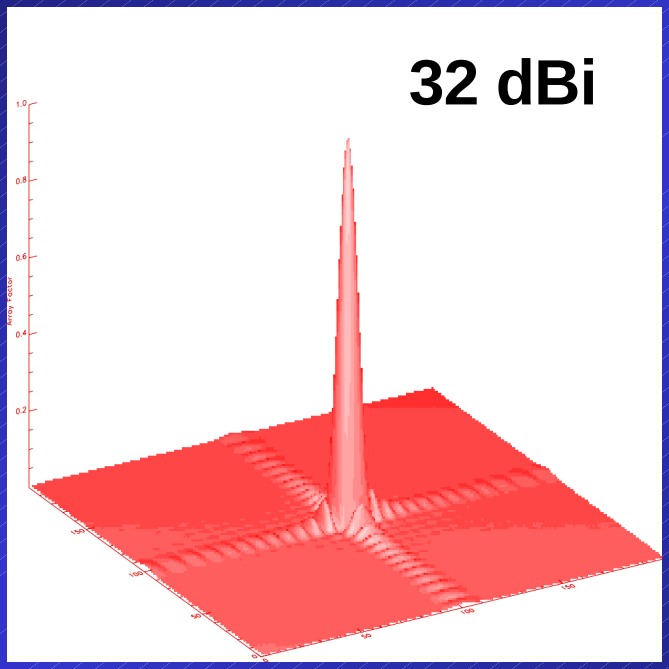
front view

array module

single layer corporate feed network



front view



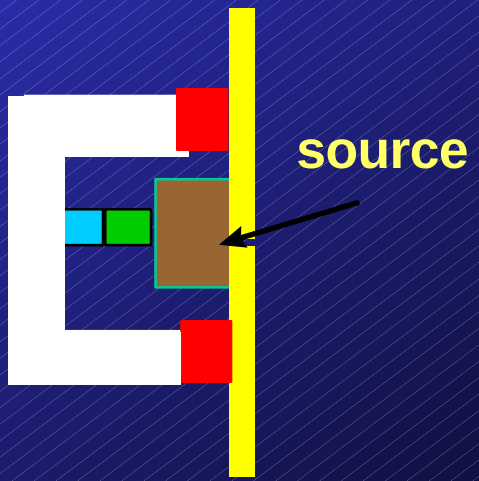
source output

first branch

second branch

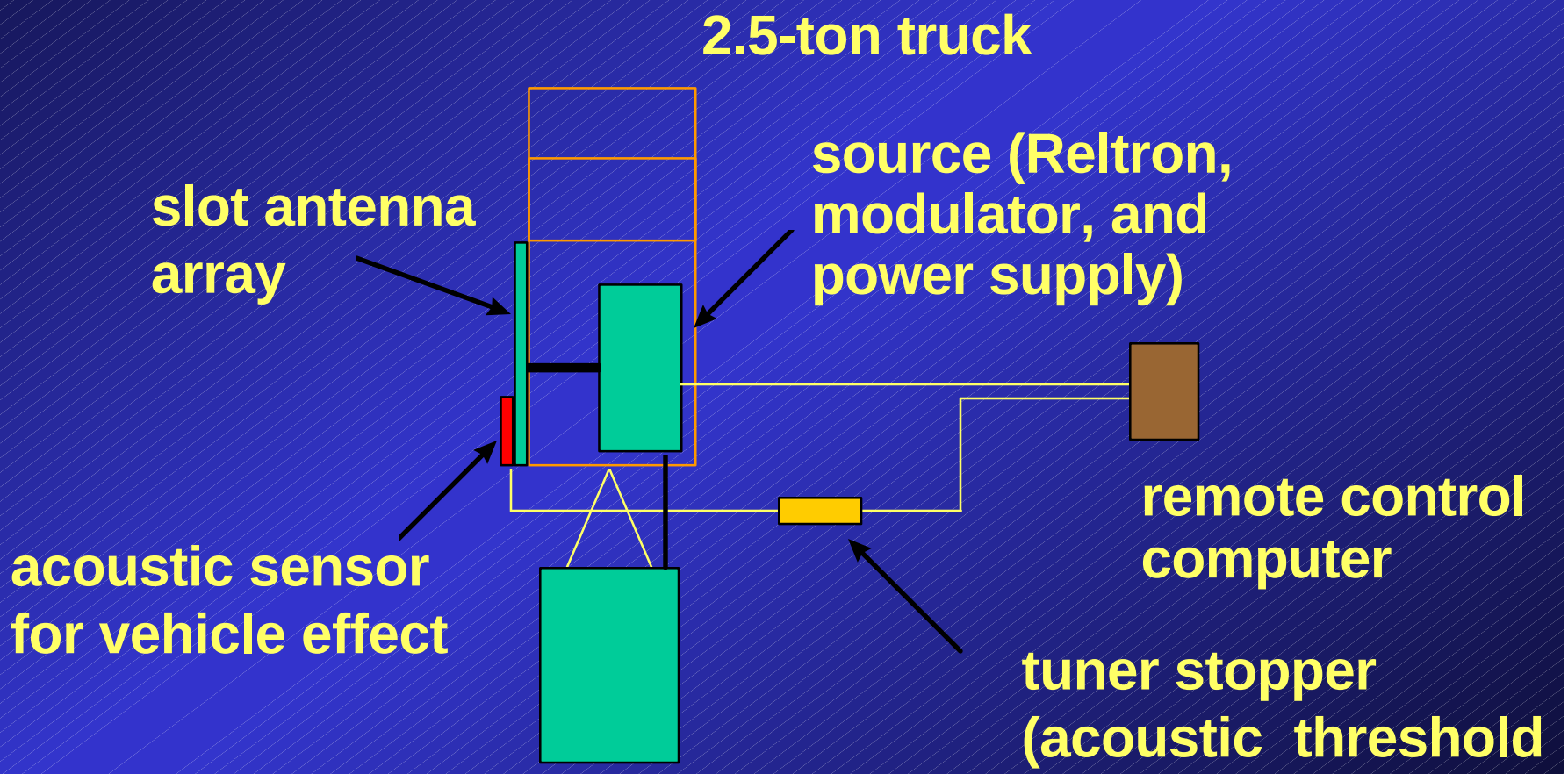
network feed

array module



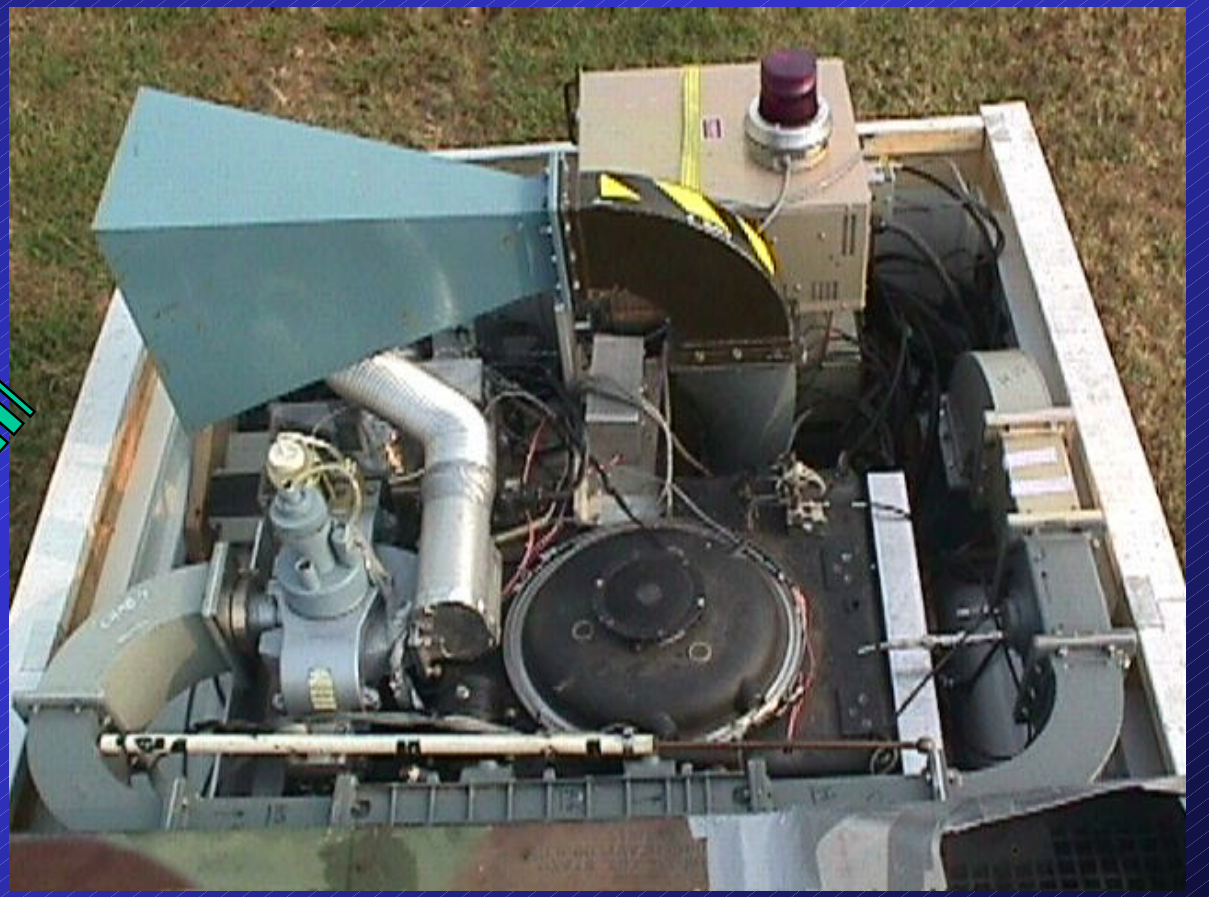
top view

Brassboard Reltron System Layout



Vehicle Stopper System for Law Enforcement

Short range system for road side applications



2-MW HPM transmitter
13-dB gain antenna

FY99 Future Work

- Continue construction of Reltron system
- Complete slotted waveguide antenna
- Evaluate Reltron system in lab testbed
- Conduct vehicle damage experiments
- Conduct field test demonstration
- Design prototype 50-MW system
  - smaller, lighter system and antenna
- Build compact 4-MW car platform system for law enforcement
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Acoustic Project Connectivity

Sponsor, **Joint Nonlethal Weapons Directorate**

- **John Busic (busicj@quantico.usmc.mil)**

Developers **ARDEC and ARL**

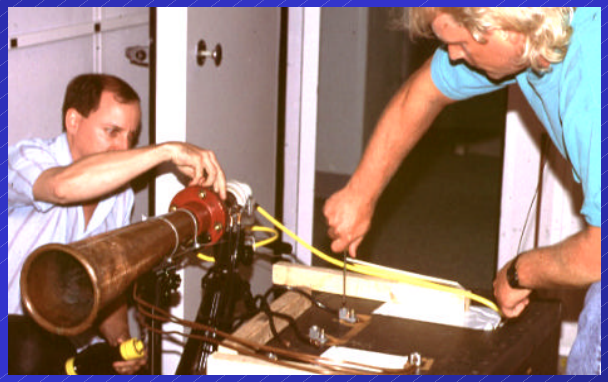
- **Harry Moore (hmoore@pica.army.mil)**
- **Ed Boesch (eboesch@arl.mil)**

Contractors

- **Adroit Systems Inc (detonation source)**
- **DE Technologies (design & engineering)**
- **Kohlberg Associates (physics)**

Objectives

- *Perform research on*
  - *sources*
  - *environments*
  - *characterization*
  - *effects*



Accomplishments

- Characterization
  - numerous field tests
  - Improved sources
  - technical advice & consultation

- SADAG source
- *HilLF acoustic test chamber*
- *analyses/models*

High Power Acoustic Source Physics and Engineering

- Impulsive Sources: Detonation tubes & electrical discharge sources
  - shock dynamics & energy coupling
  - waveform synthesis & spectrum alteration
- Continuous Sources: Air flow modulators
  - fluid dynamics, energy coupling, resonant chambers
- ARL-Developed:
  - SADAG & HiILF test facility

SADAG: Sequential Arc Discharge Acoustic Generator

- An all-electric impulsive hi-power acoustic source that is a scale model for detonation sources
  - Environmentally friendly
  - Experimentally flexible
  - Possible area denial applications
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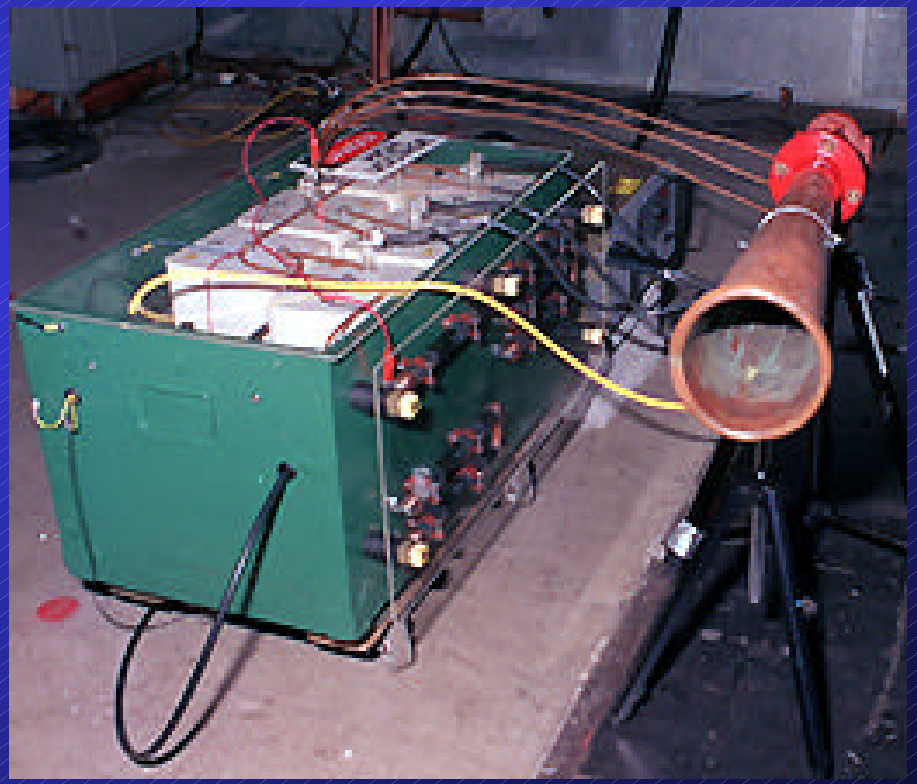
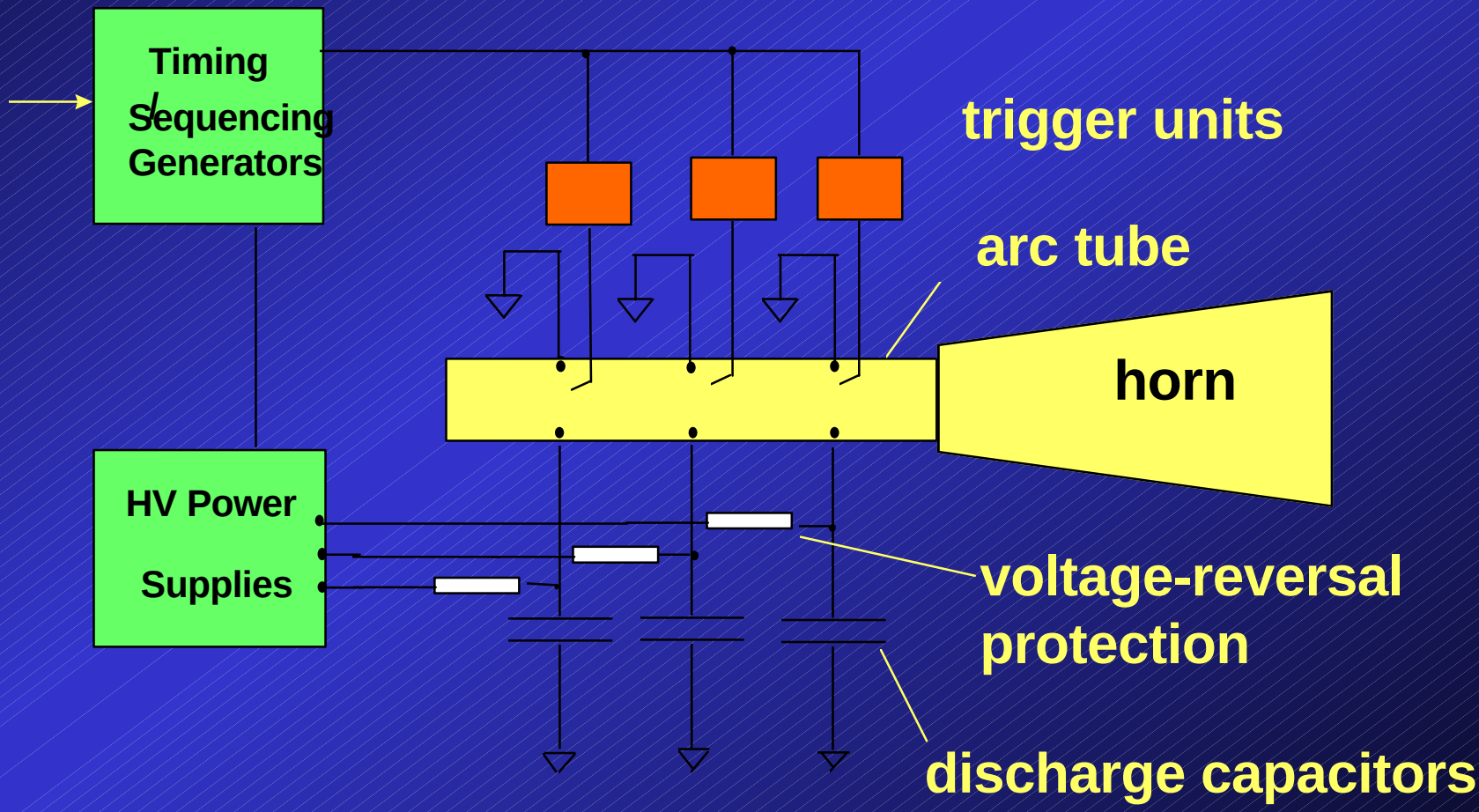
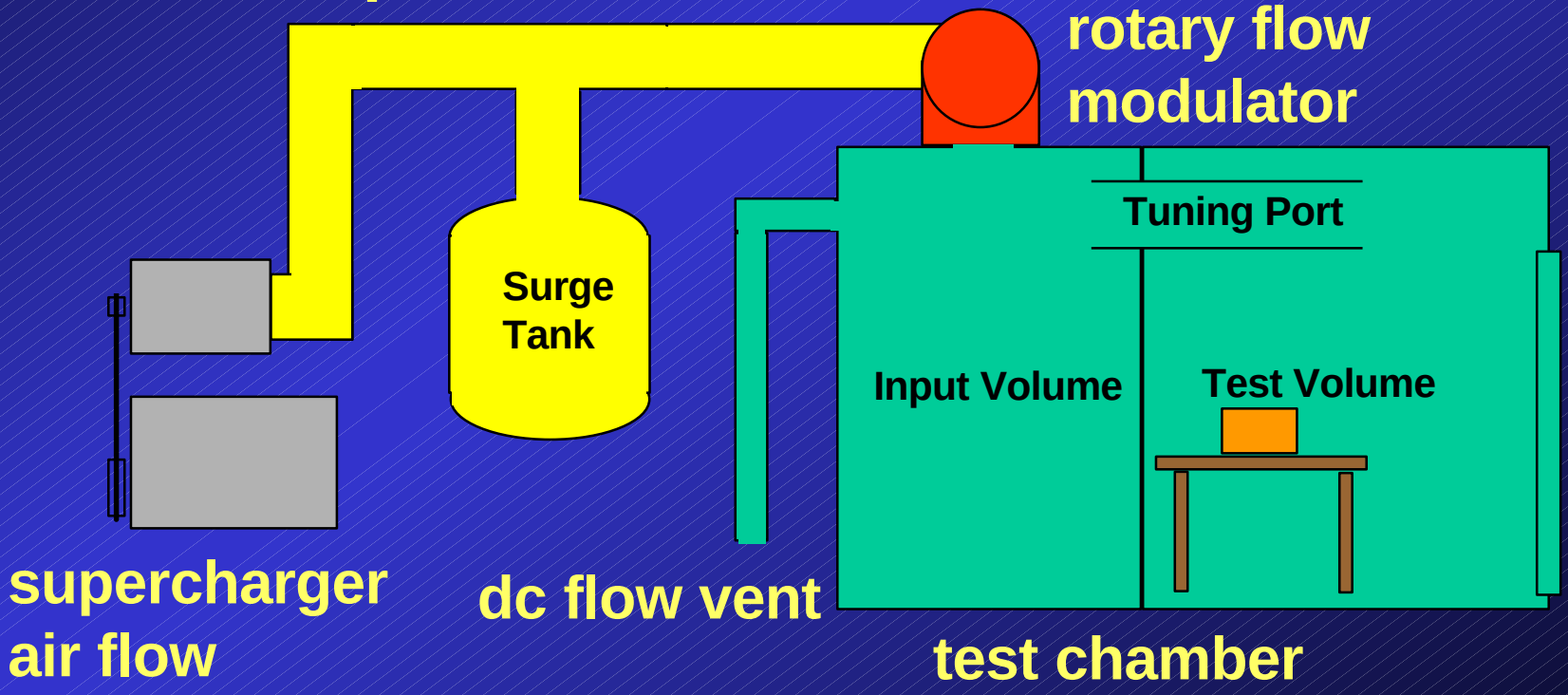


Block Diagram of SADAG



Hi-intensity Low-frequency (HiILF) Acoustic Test Chamber

- Uses low impedance rotary flow modulator and Helmholtz resonator principle to produce high intensity acoustic environment at low audio-infrasonic frequencies



Future Work

- Support near-term field demonstration
  - source physics/engineering
  - HiILF facility for target effects studies
- Continue research on hi-intensity impulsive acoustic sources
  - shock dynamics, energy coupling
- Develop advanced electrical-discharge acoustic sources for area denial applications
  - high power, synergistic optical effects
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Vortex Ring Gun Connectivity

Sponsor

- US Army Research Laboratory

Cooperative Developers

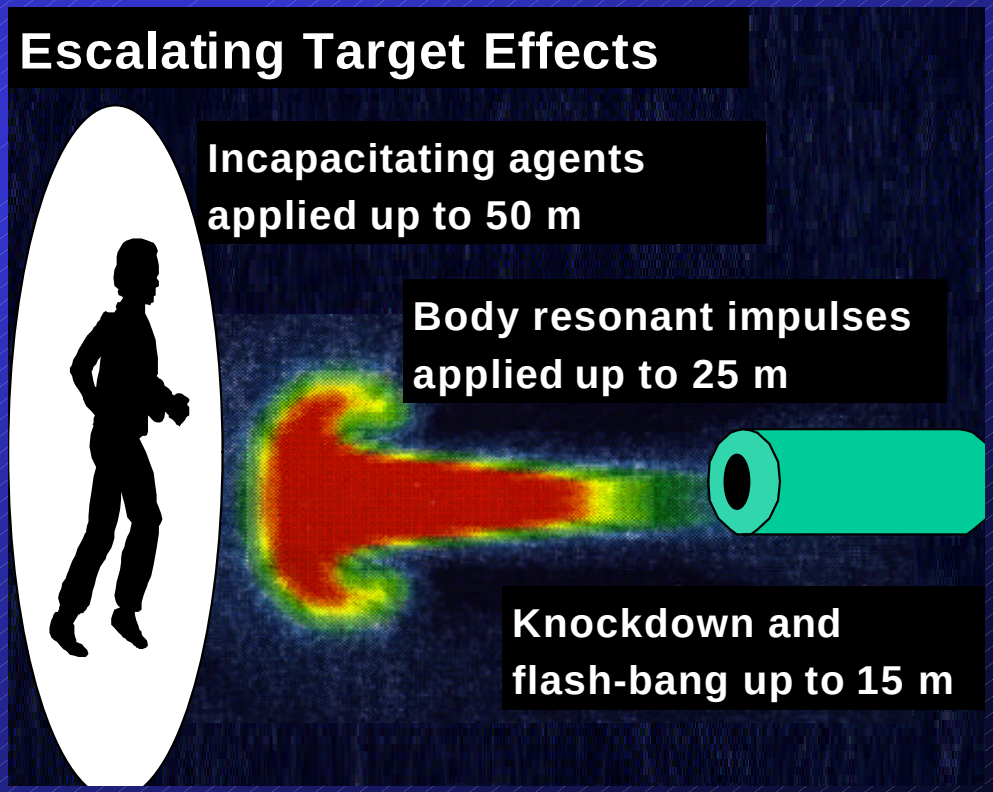
- US Army Research Laboratory
- US Army Armament Research Development & Engineering Center
- EWS Ltd.
- Pennsylvania State University
- Institute For Chemical Technologies
- Sonic Development Laboratories

Contractors

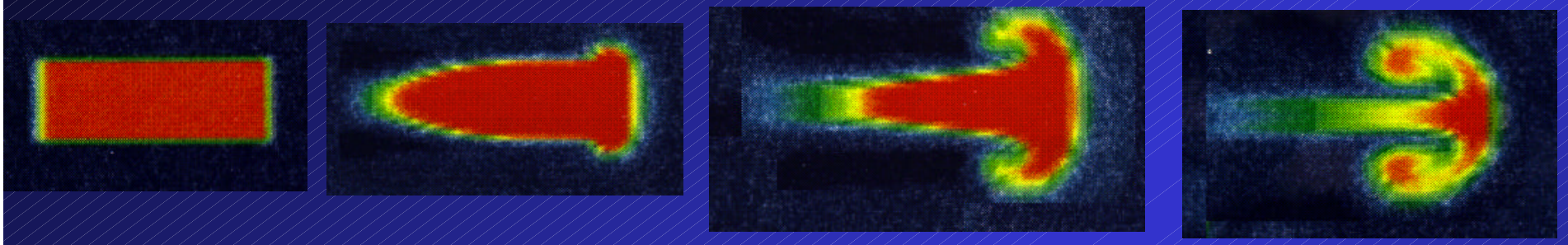
- Dr. Omar Knio, Consulting
- Berkeley Research Associates

Objectives

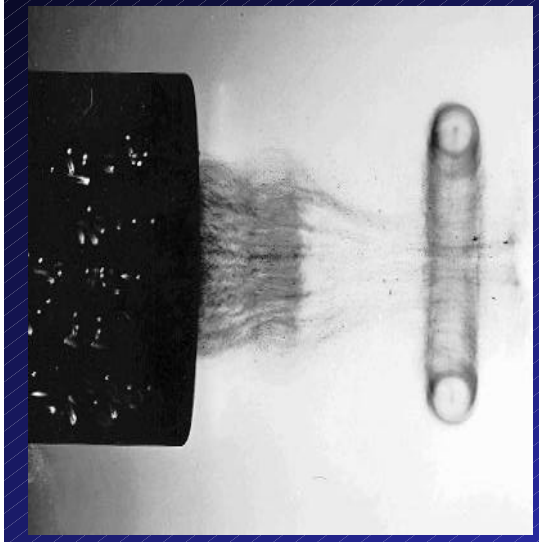
Develop a vortex ring gun for use by military police and law enforcement in non-lethal crowd control. The weapon discharges a blank cartridge into a diverging nozzle and injects an incapacitating agent into the supersonic jet stream. Spin within the vortex mixes and activates the agent in flight. Impact deposits the agent onto a target and firing at a rate in resonance with body organs magnifies the force felt by the target



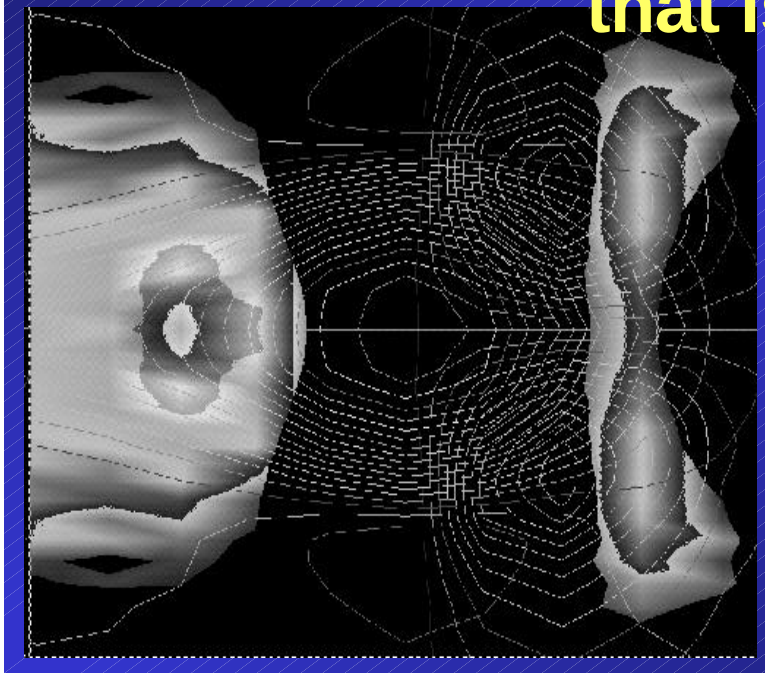
Design Guidelines For Target Knockdown



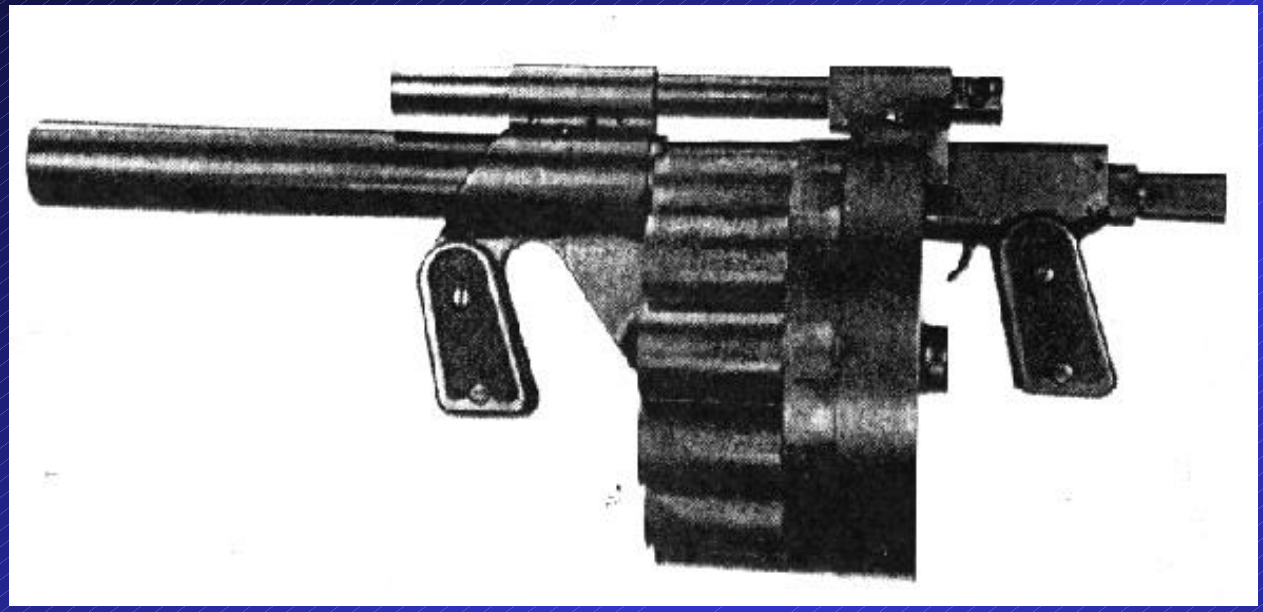
Computer modeling of a gas "bullet" is used to study the mechanisms of vortex formation without the influences of orifices or boundary conditions. In the simulation above, a hot gas cylinder is launched at high mach number and atmospheric pressure into a stationary gas. Drag slows the tip and initiates a radial flow that is inhibited by pressure from the bow shock. The continually advancing cylinder exposes a region of lower pressure that diverts the flow rearward and forms a spinning vortex.



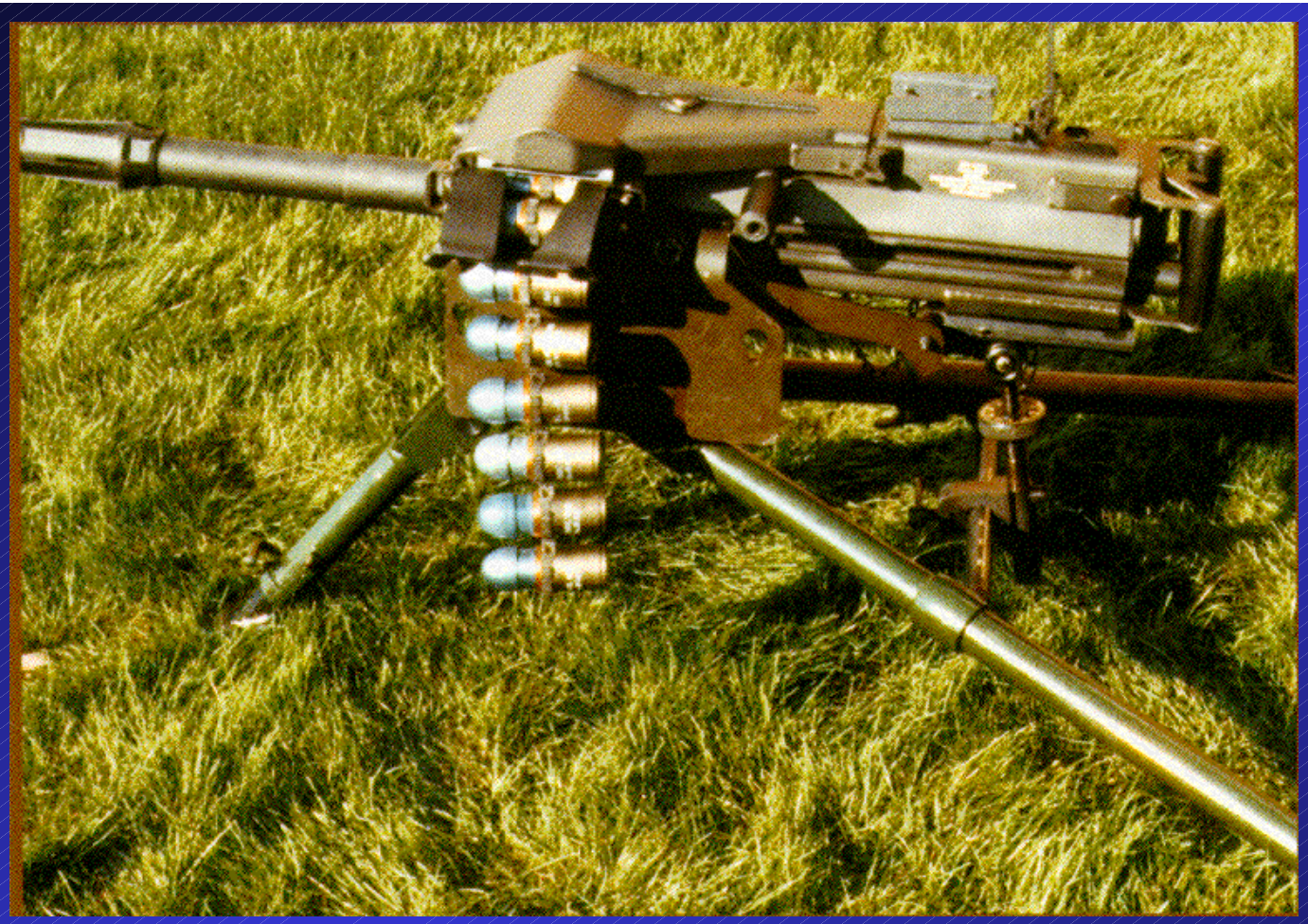
Computer analysis of a vortex ring gives the identification of physical parameters that are critical to control in gunfire to assure the optimization of target effects. Analyzing unity values of the axial and radial velocity contours locates a center for the total-velocity vectors that is close to the vortex core. The center provides an approximation of the vortex size and motion. Coupling these with analyses of fore and aft pressures leads to estimates of the mass a vortex transports to a target.



Successful Knock-down of a 150 LB. Mannequin at 30 Ft.



A candidate platform for military police and law enforcement communities is the GL-6 repeating revolver 40-mm grenade launcher. The concept is to provide a two piece kit that retrofits to the gun and enables quick conversion between lethal and non-lethal modes of operation. The kit consists of a set of blank cartridges and a disposable rod which slides into the barrel and affixes to the muzzle.



A second candidate platform for modification to non-lethal operations using vortex technology is the MK19-3 automatic 40-mm grenade launcher. Firing in resonance with body parts (~ 10 shots/sec) amplifies the force felt by a target.

Future Plans

- Concept feasibility work completed
- Military applications > 20 m
  - no work planned
- Law enforcement applications < 20 m
  - design a compact system
  - optimize vortex formation
  - conduct target effects
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Full speed & slow motion knock down demo using red chalk dust to improve visibility